Chapter 5

PETROLEUM RESEARCH UNDER SIEGE, 1946–1959

As government and industry abandoned wartime projects in the postwar period, the Bartlesville station faced severe problems of adjustment. H. C. Fowler, Superintendent in the decade and a half after the war, fought to rejustify every program and expenditure from year to year in the face of constant pressure to hold down budget and personnel. The search for "problems"—for viable research agenda items which would be both feasible and fundable—became extremely difficult. Budget ceilings, increased costs, the growth of private industrial and university laboratories that preempted whole research areas, all added to Fowler's difficulties. The outside pressures generated internal tensions; morale varied from group to group depending upon leadership, project funding, and personalities. Fowler attemped to build on the tried and true successes of the station, to preserve the best work and most distinguished divisions, and to foster a cautious search for new opportunities.

The economics of oil shaped and sometimes hampered Fowler's efforts. Imported oil from the Middle East undercut prices for American crude, forcing the Interstate Oil Compact Commission and state commissions to keep tight control on domestic production to prevent another low-price crisis like that of the early 1930s. As production in the once-flush fields of Kansas and Oklahoma declined, however, producers and commissions in those states explored means of increasing production through secondary recovery methods, especially forced injection of water. Therefore, despite the national tendency to hold down production, on a regional basis producers and commissions sought federal assistance in perfecting secondary recovery methods. Response to such opportunities had to be limited, for concern with already inflated government expenditures led the public and Congress to question a large role for government through the post-war years. Small increases in salary budget to allow for the cost of living might be acceptable; but programmatic expansion of the station to develop more waterflood expertise or other new programs was extremely difficult to "sell."

With the increased local interest in secondary methods of production brought on by the changes in oil economics, the Production division in particular faced a need to reexamine and rejustify its activities. But each of the other divisions or branches at Bartlesville also faced conditions which threatened their established purpose or function. The Chemistry and Refining branch, for example, had not dealt with refining processes since before World War II, and Superintendent Smith had recognized by the mid-thirties that refining work had become entirely proprietary. In World War II, the section under Harold Smith had done chemical evaluation of crude oil to enhance production of aviation gasoline, but the end of the war brought an end to such studies. The new thermodynamics laboratory had participated in the synthetic rubber project during the war, and the staff and equipment brought together by Huffman for determining the thermodynamic characteristics of hydrocarbon compounds, although in place, lacked a clear research agenda.

Given such conditions, it was a remarkable achievement that Fowler was able to maintain the station's activities. Sheer institutional survival required disruptive transitions and adjustments. Fowler also had to deal with increased internal friction and personality conflicts. Some of the younger staff saw Fowler's attempts to hold onto successful programs, individuals, and talent as mere adherence to tradition—the pursuit of routine for the sake of routine. Persistence paid off, however, and the decade and a half of rear-guard actions in defending funding and emphasizing past and current achievements gradually brought new monies and new projects to the station.

Financial Constraints

From the late 1940s through the early 1950s, Fowler viewed the budget itself as the most serious factor inhibiting his efforts. Federal appropriations for the center ranged between $329,000 and $498,000 per year for the period 1944–1949, and remained under $1 million per year until 1962, just before Fowler's retirement. The apparent doubling of budget over a decade and a half might appear a healthy increase, but in fact the rise in the budget was not steady, but fluctuated as advances were followed by cutbacks through the period. In the period following 1954, trust and working funds (that is, monies from cooperative agreements and contract work by the Bureau of Mines for other government agencies) regularly added over $100,000 to the station's budget. By the late 1950s, the amount from trust and working funds amounted to over $300,000 and was rising steadily. Much of that outside funding came to the station through the efforts of individuals who led the various research groups. As each group raised outside money, that funding could be used to demonstrate industry support, help justify the work of the group, and hence keep it included in the federal budget request as well. Yet the outside funding could sometimes result in a strong group finding its own share of the federal appropriation cut back or "nicked." Those branch chiefs who were good at "beating the bushes" for outside funding were quick to point out to Fowler that compensating cuts in their federal funds were most unfair, and he made an attempt to restrain such cuts.

The budget figures reveal that, in the long run, the station entered a transition period, changing from a laboratory almost entirely funded by, and responsive to, central direction from Washington into a facility working somewhat like a private laboratory—seeking grants and contracts to sustain its work. If the state contribution is omitted, trust and working funds as a percentage of the total station budget climbed from the range of 15–28 percent in the period before 1956 to a range of 30–37 percent in the period 1957–1962. For those branch chiefs who succeeded in raising funds, the reward was secure staffing, some new equipment, and more and more autonomy. By the end of Fowler's administration, the transition was complete, and the branches with the more aggressive leadership had developed the more extensive programs. Such a pattern also had disadvantages, in that the autonomy of the more independent groups worked against a demonstrable, single, coordinated program and left a legacy of internal divisions between the well-funded and the poorly funded for Fowler's successor.

Such a recapitulation of the change over an extended period makes the process sound smoother than was really the case. In fact, the growth of outside cooperative funding was erratic, as was the rise and fall of budgeted funding from year to year. Fowler faced a constant struggle, typical for many government agencies and bureaus, to justify the next year's funding and to stimulate projects that could bring in outside money, with no assurance that next year's federal or outside funding would even be up to the current year's level.

Conversely, when the Bureau succeeded in winning an increased appropriation, Fowler found it difficult to adjust the scale of activity upwards. As Fowler noted when the 1957 budget appeared likely to meet request levels, "if we would get all of the money that we estimated we could use in 1957, the step-up from the 1956 level would be so great that we couldn't meet the impact of the increased activity, particularly because of the dearth of qualified personnel."[1]

Despite Fowler's ritualistic complaints about budget limits, however, the station's budget and program grew under his direction, even taking into account the offsetting postwar inflation in supply, utility, and salary costs. The average hourly earnings of United States workers climbed from $1.00 per hour in 1945 to $2.00 per hour by 1957. The consumer price index, taking the period 1947–1949 as 100, had climbed twenty-six points by the end of the 1950s. In the face of low, but persistent, inflation, the apparent doubling of the Bartlesville station's budget between 1949 and 1959 still represented an average of 5 percent real growth per year.

More seriously limiting than the budget itself was the changed marketplace for new talent; in the year 1948–1949, a "sellers' market" developed, and younger men recently graduated from chemistry and engineering programs tended to be attracted to private industry. Fowler and his associates recognized the job marketplace as a major problem throughout the period of his directorship. The Production group, in designing its 1956 budget, noted: "The continuing difficulty of recruiting and retaining petroleum engineers and the inability of the Bureau to compete with the petroleum industry presents a serious problem in program completion. Recent advances in salary ceilings in the lower grades may partially alleviate this condition." The thermodynamics group faced a similar problem: "lack of sufficient funds for a fully adequate staff," as well as the perennial problem of inadequate funding for equipment. Fowler and his branch chiefs believed they could attract a first-class staff if they could get additional budget; funding, they said, was what hampered all efforts to meet program objectives.[2]

During the war years, a number of women had been hired at the station as chemists and researchers. But with a series of post-war reductions in force, most of these women were dismissed for lack of seniority. Cleo Rall, the wife of Bureau chemist Harry Rall, had earned an M.A. in chemistry prior to the war. With the departure of some Bureau technicians during the war, Mrs. Rall went to work at the station, supervising the routine analysis work in the Chemistry group. On the day after the Japanese surrender, she went into Smith's office to offer her resignation "to make way for the boys" who would be returning. Smith demurred, and she stayed on until 1953 before she retired for health reasons. But Cleo Rall was not typical, and there were few well-qualified women available to fill the openings for scientists and technicians. A number of less highly credentialed women who had worked through the war years were rather rapidly dismissed during post-war reductions in force.[3]

Fowler attempted, with no apparent success, to arrange the transfer of several women lab assistants to Laramie or to the oil shale experiment station at Rifle, Colorado. At Laramie, the response was particularly blunt: "We would rather have men. At present, the conditions under which we work are not very desirable for women workers and there are also certain other limitations." Despite Fowler's efforts to find jobs for loyal staff, therefore, the reductions in force fell more heavily on the recently hired women than on the long-term men employees.[4] As a consequence, by the late 1940s, the staff at the station tended to represent an older, largely male, pre-war generation of technicians with training only at the bachelor's degree level.

National Oil Policies

The conservatism and slow adjustment at the Bartlesville station during the 1950s stemmed, at least in part, from larger, deep-seated national factors. In Washington, the Bureau of Mines itself had become set in its ways. Since it dictated the control of manuscripts, funding ratios, and even the station's mission, this was bound to have a stifling effect on station operations and policy. But new interests on the part of petroleum producers represented by the Interstate Oil Compact Commission and regional associations, new concerns of refiners represented by the American Petroleum Institute (API), and new opportunities and problems brought on by the development of gas pipelines to which the American Gas Association (AGA) sought solutions meant that priorities set outside the government could possibly create new roles for the station if the station could adjust.

Throughout the period of Fowler's administration, however, the station's response to outside definitions of priorities remained ambivalent. On the one hand, such initiatives could provide funding and proof of the industrial utility of government research cooperation. On the other hand, Fowler and some of his staff feared that the increasing power of the private sector to set priorities and determine research agendas could represent an infringement on the station's independence. The government laboratory, if it worked too closely with the oil industry, would risk abdication of its role as an objective and neutral influence in petroleum technology. Fowler tried to steer a safe course between the alternatives of private sector support and private sector dictation of government's role.

In 1948, the Gavin Amendment expanded an appropriation for synthetic fuels research, originally set up in 1944, and authorized $1 million for research in methods of increasing recovery of conventional petroleum. Men at the station, in coordination with workers at other stations, prepared a set of proposed studies which would tap that source of federal funds and begin a detailed review of marginal wells in the Oklahoma area. Yet most of the synthetic fuels money went to Laramie and Rifle. Some individuals, particularly Boyd Guthrie and Dan Lankford, transferred to Rifle to work on synthetics.

Although the secondary recovery funding came through congressionally appropriated funds, the Bureau reported on work under the Gavin Amendment both to the government and to the Interstate Oil Compact Commission's Committee on Secondary Recovery. Recognizing the political influence of the oil compact states in securing the appropriation, Fowler presented a report in 1948 which was published in the Compact Commission's own *Quarterly Bulletin.* Through 1949, the Bureau continued to report to the Compact Commission on Gavin fund expenditures and plans, showing how engineering field studies in Oklahoma, Texas, Wyoming, California, and Pennsylvania related to the secondary recovery objectives of the funding. Specific projects at the Franklin, Pennsylvania, station, at the San Francisco Field Office, and at Bartlesville were also pertinent to the import of the Gavin funding.

Perhaps the most important result for Bartlesville of the Gavin Amendment was the organization of the Basic Production Research Group. This group laid the foundation for later work in enhanced oil recovery methods. Specific projects at Bartlesville that related to the secondary recovery interest in the 1950s included: locating abandoned wells through use of metal detectors, study of water-conditioning plants, study of the effect of dissolved gases on corrosion of metal, studies of rates and pressures of water injection, core and water analysis, and proposed uses of radioactive isotopes as tracers.[5]

Fowler also planned, with the funds provided in the act, further work on ideas for two tools under development by the Production group: a liquid level gauge and a well-bore caliper. The liquid level gauge would help determine the flow of water from water injection wells into productive sands; the caliper would determine the inside diameter of well cavities. This information might allow for more accurate determination of the flow and direction of water used. In 1952, the station filed for a government patent on the gauge. But the design of the well-bore caliper represented a "formidable" problem, as it had to be capable of being inserted through a 2-inch bore, then expanded to measure cavity diameters up to 36 inches to an accuracy of 1/4-inch, then collapsed for withdrawal through the tubing. The umbrella-rib-like design was to be ready for field tests in 1949. The project eventually led to a workable design, which was patented in 1956.[6]

By 1953, the Eisenhower administration cancelled the whole synthetic fuels program and the extra funding for secondary recovery work, due partly to industry pressure from integrated multinational firms and partly to the increased quantity and supply of crude oil coming in from Middle Eastern sources. The local rise of expectations and subsequent cutback was part of the much larger national debate over sources for petroleum fuels.[7]

In 1948, oil industry analysts recognized that the United States was at a turning point in its energy supplies. In 1947–1948, for the first time, the nation imported more petroleum than it exported. American-based independent oil producers sought a duty on foreign oil, a duty that the coal and oil shale states advocated be used to subsidize an extensive synthetic fuels industry, converting solid fossil fuels into liquid products. But the cost of imported oil, even with the addition of a duty, remained lower than American crude oil; oil imports continued to grow. Although not a "glut" of oil in the same sense as the East Texas boom of the early 1930s, the flood of foreign oil led to continued limits on domestic U.S. production.

Fowler expressed considerable doubt about oil shale as a source for synthetics, despite the national program for synthetic fuel research in the period 1944–1953. Bartlesville itself did not have a direct role in oil shale work, most of which was conducted at Bureau of Mines facilities at Rifle, Colorado, and at Laramie, Wyoming. Another facility at Louisiana, Missouri, studied processes for the hydrogenation of coal. When Ambrose, now a Bureau alumnus holding the position of president of Cities Service Oil Company, sought estimates of commercially available and recoverable oil shale, Fowler offered a critique of earlier Bureau of Mines estimates that some 300 billion barrels of oil from shale might be in reserve in Colorado, Utah, and Wyoming. Accounting for the need to leave supporting pillars standing in an underground mining program, and estimating a recovery rate of about 15 gallons of oil per ton of shale, Fowler thought that ultimately recoverable oil might amount to 200 billion barrels. Even when discussing such vast quantities, however, he retained a cautious and conservative tone. "Assuming that 75 percent of the shale can be mined, that satisfactory methods for retorting all of the mined shale can be developed," he thought the 200 billion barrel estimate "not unreasonable."[8]

Fowler obtained his information by sending queries to others in the Bureau who were working on various aspects of shale, including J. D. Lankford at the Rifle, Colorado, shale station, and Boyd Guthrie, head of the Rifle facility and regarded as the Bureau's leading shale expert. Both men had previously worked at Bartlesville.[9]

On the local level, Harold Smith became a minor advocate of synthetic fuels, while Fowler continued to indicate cautiously the limits of the resources. Smith became an instant expert on synthetic liquid fuels when he was invited to make a guest appearance at an "Information Please" session of the Natural Gasoline Association meeting in Ft. Worth in 1948. Although Smith was well known by the natural gasoline people, and was invited because of his contacts, he was not in fact a specialist in synthetic fuels. He worked furiously to build up his own knowledge to be able to handle the session, seeking help from R. M. Gooding in the Office of Synthetic Fuels at the Bureau of Mines headquarters in Washington, who supplied him with reports and data. At the time, retorted oil from shale cost $2.50 a barrel in raw material cost, not taking into consideration the actual cost of refinery construction. This price did not compete with the going rate of $1.75 per barrel for petroleum crude. Smith used Gooding's material, and the two jokingly noted that a bit of reading made one a "synthetic fuels expert" almost overnight.[9a]

On a national level, synthetic fuels and secondary oil recovery received only modest and short-lived support. But on a state and local level, in the mid-continent, interest in secondary recovery methods of increasing domestic oil production ran high. Policies laid down by state commissions tended to foster the development of marginal or stripper oil wells. In most states, those wells producing less than 10 barrels a day were not subject to limitation on the number of days per year allowed for production. For this reason, a marginal well of low production could be more desirable to a producing company than a more efficient, high-production well. Consequently, the mid-continent region saw a great growth in interest in secondary production of the older, marginal wells.

Of particular interest to Bartlesville in the immediate post-war period was the opening up of waterflood projects in Nowata County, Oklahoma, due east of Bartlesville, and in nearby counties due north in Kansas. Waterflood techniques had been discovered accidentally in Pennsylvania as a result of an illegal disposal of water into an oil well. As a means of increasing production, the method became popular in the 1920s as older wells lost pressure. By injecting water under pressure, oil could be forced to producing wells. Bureau of Mines investigators had studied the technique, and some producers experimented briefly with the methods in Oklahoma in 1930 and in Pennsylvania during the war, in cooperation with the Bureau's Franklin office. The great boom in domestic oil production in the 1930s decreased mid-continent interest in waterflooding, but when Oklahoma wells declined in the post-war years and state policies excluded the low production wells from proration, the technique became economically and technically viable. Secondary recovery remained of interest in the mid-continent region, and the Interstate Oil Compact Commission, which represented mid-continent oil regulatory commissions, monitored developments closely through the period.[10]

For a period of over a decade after World War II, the Bureau of Mines at Bartlesville hosted waterflood tours. Small independent producers, as well as petroleum production specialists from larger firms such as Phillips Petroleum, would gather for one or two auto caravan tours of waterflood projects per year. Kenneth Johnston, a petroleum engineer who had joined the station in 1942, arranged the details of the tours, charging $4.00 to each member of the group to offset the cost of the barbecue and beer that ended each tour. As many as 125 cars, escorted by the Oklahoma Highway Patrol, would carry 400 to 500 participants to a number of field projects. Printed handouts prepared by Johnston gave details of the various projects, and the tours served as a kind of "moving convention" of local producers, who used the opportunity to exchange information and to enjoy a social get-together.[11]

Comprehensive studies of projects to be toured were compiled as Reports of Investigation or Information Circulars and published for distribution to tour participants. Most of these were written by J. P. (Jack) Powell, J. L. (Les) Eakin, or Kenneth H. Johnston either alone or in collaboration. In addition to their technical content, a popular part of these reports was the detailed 3-dimensional drawings of each project prepared by Joe Lindley, Engineering Technician with the Bureau of Mines in Bartlesville.

These waterflood tours brought the station considerable regional notice and support through the late 1940s and the early 1950s. In fact, they were probably the single most important activity of the station in this period, at least when measured in terms of their public relations value among mid-continent oil producers. No other activity drew such measurable regional interest and attendance. In one sense, the tours represented a reversion to the demonstration style of operation characteristic of the early 1920s. But in another sense, they reflected also the effort to adapt to the changing economic factors confronted in the post-war decade.

In the mid-continent, smaller producing companies and regional associations of producers continued to request Bureau of Mines studies. And through the late 1940s and the 1950s, the station continued to produce field engineering studies of various oil-producing districts. As in the 1920s, the station gathered well information from producers, collected data on production rates and decline in production over time, and published reports. In 1947, in response to a request from the North Texas Oil and Gas Association, the station gathered data for a study of waterflood results in North Texas. In 1948, the station collected data on the Healdton field in Carter County, Oklahoma, one of the earliest major producing fields in the mid-continent region. In 1949, Wade Watkins of the station worked closely with the Kansas-Oklahoma Water-Flood Operators on questions of injection well spacing.[12]

The Bureau's traditional avoidance of areas of research in which the larger firms conducted competitive work had an increasingly limiting effect as the private research of the large firms expanded after World War II, even though Bartlesville continued to cooperate with local small producers and regional associations. Over and over, Fowler reminded others that their proposals came dangerously close to areas of private research. In 1956, for example, he warned against work in rock physics: I "feel that the Bureau should be very careful not to get into a field that is already preempted by industry and probably one in which industry can do a better job than the Bureau . . . I can see where the Bureau could spend a great deal of money in that area of research, and it might lead to proprietary questions and patent claims if the study were not watched closely." Similarly, he argued against proposals for work in offshore oil engineering, on the grounds that commercial specialists preempted the research. The highly technical problems, he feared, would constantly place the Bureau in the position of competing with proprietary developments.[13]

An incident which shed light on Fowler's style in handling relations between the Bartlesville station and industry on an extremely local level developed during this period. In 1949, the historian Carl C. Rister wrote *Oil! Titan of the Southwest,* naming as the first commercial oil well in Oklahoma, not the Nellie Johnston #1 drilled in 1897 in Bartlesville, but an entirely different location six years earlier than the Bartlesville well. The local Chamber of Commerce, representing local oil history pride, protested the work in its draft stages, and Rister finally included a statement that Nellie Johnston was "alleged to be the first commercial oil well in the state." The issue stayed alive, Fowler asked Cattell to keep the Bureau from getting involved. In 1953, a Bureau of Mines film, in its early stages, followed Rister's lead and referred to 1891 as the beginning of commercial production of oil in the state. Sensitive to the local pride involved, Cattell set about having the reference in the film removed. He did so, however, not by noting explicitly the potential political problem, but by developing a thorough and detailed scholarly analysis of the historical incidents of oil discovery in Oklahoma, which pointed out that the whole issue of first claims was fraught with ambiguity. Sending this document to the Bureau of Mines division chief in charge of the motion picture project was successful in getting the reference deleted. The fact that Fowler regarded the incident as potentially "embarrassing," rather than either an amusing critique on local pride or an opportunity for scholarly argumentation—as did Cattell—reflects the cautious and conservative style that Fowler brought to walking the tightrope of relations with the private sector.[14]

In another incident reflecting his style, Fowler reacted with considerable alarm to the fact that, in 1955, the API Mid-Continent District Study Committee on Core Analysis appointed an industry group to gather information and report on underground brines found in petroleum drilling. Both Fowler and Wade Watkins, petroleum engineer, perceived the API activity as an inroad into territory that had long been dominated by the Bureau; they felt it unlikely that the Institute and the Bureau could cooperate on a joint study. Fowler's reaction was to deemphasize future water studies at the station, to bring quickly to publication work pending on Oklahoma brines, and to coordinate future work without duplication of effort. "I think we should check carefully with the API to find out if there is to be an overlap in the other areas where we have been collecting . . . water samples and put our emphasis on water studies that industry is not in a position to do."[15]

On a national scale, the development of research facilities by integrated firms could only limit the role the government's laboratories might play. Industrial laboratories grew to dominate the research effort in petroleum. In the post-war years, extensive veterans' benefit programs swelled enrollments in colleges and universities, giving a boost to university research. The growing university facilities provided training and experience for industry technicians and scientists, replacing the modest part that Bartlesville had once played as a training ground.

Although private research might have a limiting effect on the station, it could also produce some benefits for the station's research program to the extent that the station could react with flexibility to industry initiatives. For example, when the API began its coordinated research project on sulfur compounds in petroleum due to increased marketing of sulfur-laden petroleum from U.S. fields and from abroad, which continued from 1948 through 1965, the laboratories at both Laramie and Bartlesville obtained small parts of it. Work at the Laramie station on the sulfur project included synthesis, purification, and determination of properties of sulfur compounds. Work at Bartlesville included determination of thermodynamics data of sulfur compounds, and separation, isolation, and identification of sulfur compounds in crude oils. Funding at Bartlesville varied for the two projects, totaling between $10,000 and $26,000 per year for the life of the projects. Related research on other aspects of the problem was carried on at university and private industrial laboratories. A similar effort, dealing with nitrogen compounds, continued from 1954 through 1966. Both projects allowed for Bartlesville to support work in its thermodynamics laboratory.[16]

In later years, the participation of the thermodynamics group in these two API projects was remembered with an ambivalent mixture of pride and embarrassment. On the positive side, the fact that the laboratory had Ph.D. chemists with the skill and equipment to produce technically excellent and accurate characterizations of compounds could be seen as a tribute to the national and international repute of the Bartlesville station. And the API funding over an 18-year period demonstrated that the station earned industry recognition and approval for its work from the major national industrial association in petroleum. Yet the repetitive nature of the work, and the fact that such studies were not innovative but simply the development of "handbook data" directed by an outside group, suggested to some that the station's top scientists were engaged, not in pure research, but in a sophisticated type of busywork, an elaborate exercise in routine, directed by outside administration. Such critics were not able to recognize the fact that handbook data were essential to the design of processes and equipment.

Bartlesville cooperated through 1951 and 1952 with the U.S. Geological Survey and the Petroleum Administration for Defense (PAD) in conducting a field survey of the Scurry Reef oil field in west Texas. In an effort with echoes from World War II research, the survey was taken on as part of the PAD reaction to increased demand during the Korean War. The engineering field study used data on reservoir fluid and reservoir rock obtained from cores to arrive at an estimate of the volume of oil originally in place in the reservoir. Such studies would help yield estimates of total U.S. reserves. Using techniques and principles developed by Ken Eilerts, the station submitted details of the prospective effects of repressurization, which could increase production of gasoline-rich fluids, even after cooperation with the Petroleum Administration for Defense came to an end in mid-1952.[17]

Throughout this period, Fowler developed and improved the procedures for obtaining new outside funding. Responding to developments in oil technology, a group or individual at Bartlesville would rapidly develop a proposal and attempt to sell it to an outside agency or association. If funded, the individuals who developed the proposal would see the project through to implementation. The process did not always work, but it provided a system of incentives that favored the more energetic and imaginative researchers. The economic adjustments of the post-war era created a host of opportunities in petroleum research. Although some of the men at Bartlesville responded, the net effect of the rapid changes in petroleum research, as noted earlier, especially the growth of industrial laboratories, was to diminish the station's proportionate importance.

The political atmosphere of the 1950s aggravated this trend by stressing the virtues of private enterprise and limited government expenditures. The vast growth of both private and university laboratories preempted areas of new technology. The massive increase in imported oil tended to retard interest in research into new methods of increasing production, with the exception of regional interest in waterflooding. In 1928, the Bureau had been at the center of petroleum research, particularly in studies of underground formations and in petroleum engineering; twenty-five years later, by the mid-1950s, that central locus of research had moved to the private sector, despite the station's newly added scientific capabilities. It seemed to Fowler and the Bartlesville researchers, despite their best efforts, that there was little they could do to regain the central place once held by the station.

Internal Stress and Achievement

At the same time that national trends reduced the importance of the station, local and internal problems exacerbated the difficulties of the post-war transition.

Fowler, a civil engineer with background in safety engineering who had worked at the Washington office, had been selected as Superintendent in 1946 over Harold Smith, an accomplished chemist who enjoyed a national reputation. Although both men, as professionals, were able to work together, increasing tension built up between them. In 1954, Smith was selected by the Bureau of Mines to be Director of "Region IV," which included Texas, Oklahoma, Arkansas, and Louisiana. The headquarters of the Bureau region was shifted from Amarillo, Texas, to Bartlesville to accommodate Smith, and he operated the regional office from the Post Office Federal Building, several blocks from the station. Although such a post would appear to put Smith in the line of authority over Fowler, Fowler continued to deal directly with the Petroleum and Natural Gas Division of the Bureau of Mines in Washington, providing Smith only with copies of selected memoranda.

Smith was put in charge of the region as part of an effort from headquarters to decentralize the Bureau and to make field facilities more responsive to local needs. But Fowler and Taliaferro (head of the Secondary Recovery Division at the station) preferred central to regional coordination and reminded Cattell at headquarters from time to time of a host of inefficiencies which sprang from funding a regional office. The strategy, claimed Taliaferro, "is contrary to the accepted good management practices followed by major oil companies," and resulted in duplication of work from region to region. Taliaferro also argued that funding a regional office took money away from research.

Consistent with this view, Fowler and Taliaferro supported the establishment of "steering committees," particularly in production, arguing that this would bring together researchers from various regions and avoid duplication. Although ostensibly designed to eliminate duplication of projects, the steering committee also had the clear effect of preventing regional directors like Smith from designing a regional, rather than a national, plan. By 1956–1957, it became clear that Smith would not win increased power as a result of decentralization. Indeed, Smith won very little support from Washington in the struggle. And by the late 1950s, the Regional office had become less important than the station Superintendent office, as Fowler continued to be able to work with Washington as if the Regional level did not exist.[18]

Fowler sometimes criticized technical "people," without naming Smith directly, who were promoted to administrative tasks. Furthermore, suggestions for administrative reform and research agendas advanced by Smith received severe and pointed critiques by Fowler and others at the station. In at least one case, plans for a conference advanced by Smith were thoroughly reviewed at the station and critical comments forwarded to headquarters.[19]

Other examples of more minor disagreement appeared between the two men. Smith developed a plan for keeping senators and congressmen from the region posted as to recent work of the station. He also worked to keep Bartlesville in the local papers. He prepared a detailed story on recent activities, for example, and had Taliaferro lend his name to it to have a local author as authority. In a report on the issue to Fowler, Smith recommended that a similar story be issued every three to four weeks and be sent to the local Bartlesville newspaper, the *Examiner Enterprise*. Fowler did not adopt the plan as set out by Smith.[20]

Other issues of personality, politics, and career path deepened, rather than ameliorated, a tendency toward stagnation at the station. Station scientists generally respected the thermodynamics section—headed first by Huffman during the war years then in turn by Guy Waddington, John P. McCullough and Don Douslin—as the elite of the laboratory. These men were Ph.D.s, dedicated to rather pure analytic problems, giving the group a style and manner that set it apart from much of the rest of the station. Although the two projects with API during the late 1940s and early 1950s provided the thermodynamics branch with a set of specific problems and a raison d'etre, the more academic and scientific (rather than practical and engineering) nature of the branch and its work, its established and repeated funding from API, and its consequent insulation from year-in and year-out struggles for outside funding, tended to keep it from developing the further industrial contacts and leads for new work that characterized the Production, Secondary Recovery, and Chemistry-and-Refining Divisions.

An undercurrent of tension through the period may have reflected the larger difference between the styles of those with training as scientists, particularly the chemists, and some of the petroleum technologists with training as engineers. The fact that Fowler, a civil engineer with little scientific background, supervised the work of accomplished scientists, some with training at the doctoral level, contributed to the undercurrents of disunity. All the staff recognized that loyalty to the station and to its leadership through the years of tight budget was necessary to survival. Yet when difficulties arose—such as reductions in force, division and use of scarce funds, assignment of staff to particular projects, or the acquisition of outside funding—the tensions would surface.

The division between scientist and technologist was not, of course, perfectly clear-cut. Since much of the scientific work of the station grew out of the need for technical solutions to practical problems, scientists suffered from the problems of technology: the demand for timely results for immediate needs. The work of Eilerts exemplified the dilemma of scientist-as-technologist.

Since 1936, Eilerts had been studying phase relationships in gas condensate wells, continuing to work towards the publication of a massive monograph. By the 1950s, he was in charge of an autonomous research group within the station to continue his work. The work reflected a sophisticated study of pressure-volume-temperature relationships of various gas condensate mixtures in different fields; but the fact that the project took over twenty years to finish limited the participation by Eilerts and his assistants in other problems and projects. He regarded a four-year project in the late 1940s dealing with the corrosion of oil well casings and tubing as a digression from his work on the monograph, for example, but he had to do it. So he fought to wrap up the shorter project quickly so that he could get back to his gas condensate work. His report on corrosion indicated that chrome alloys corroded far less than unalloyed steel, and the chromium alloys were widely adopted. Even on this short-range project, Eilerts was dissatisfied as a scientist, because the need for timely results prevented determination of the exact reasons for the better survival of chrome alloys under petroleum and gas contact.

Although others respected his long-term project, the extensive time involved in the gas condensate study and its probable irrelevance to market conditions when eventually published caused some resentment among his colleagues. Later, even Eilerts himself acknowledged that he had been too much of a perfectionist and that the project, when completed, attracted less attention than it might have if published some fifteen years earlier. When he began, the practice of pumping dry gas from wells which produced a mixture of wet and dry gas back into the underground formation had made economic sense, since the alternative to repressurization and underground storage was simply to release the dry gas and to flare it after removing the liquid fractions to refine into products.[21] But with the spreading construction of gathering and transmission gas pipelines in the post-war years, most dry gas produced in the field could be economically marketed, and was thus no longer available to repressurize the formation. Therefore, details of the liquid-vapor point of the mixtures of particular hydrocarbons present in various fields had far less practical significance when he finally published them in 1958 than they had earlier. Eilerts' scientific work was fifteen years too late for the market. He did not personally despair, however. On completion of the project in the late 1950s, Eilerts engaged in a program of computer applications to the study of underground formations, earned himself a masters degree in mathematics in 1963, and set off on a new course of research.[22]

In a sense, the pursuit of various projects by talented, well-trained, and powerful individuals like Harold Smith, Waddington, Douslin, and Eilerts tended to proceed in some isolation from one another and from the work of the rest of the station. Whether this development could have been offset by a more effective administrative style than that displayed by Fowler is, of course, a difficult question; but the answer may well be yes, at least to some degree. Many researchers at the station admired and respected Fowler as an administrator, and as a man of complete integrity. But the spirit of teamwork that had prevailed under the leadership of Nick Smith appeared to decline, and Bartlesville increasingly lacked the congeniality of joint ventures.

Efforts to Secure Outside Funding

Although the station suffered through readjustment, it remained active, generating a series of studies and reports, many of them useful and timely to the technological needs of the petroleum industry.

In 1955, the Production and Secondary Recovery groups at Bartlesville met with colleagues from Laramie and from other Bureau offices to plan priorities and research objectives. However, the meetings resulted largely in a program to eliminate duplication of work between the stations and resulted in recommendations for decreases, rather than increases, in budget and staffing. Even before the conference, Bartlesville's Watkins expressed his "firm belief" that the time was ripe for "an evaluation of the Bureau's petroleum-production research programs and for some action designed to eliminate duplication of effort and misdirected efforts (if any)."[23] The meeting became a platform attacking decentralization and the authority of regional directors like Smith to design local research agendas. The ideology of efficiency and reduction of waste, long the motto of the station, when applied to government itself, did not lead to new projects. Efficiency as a goal produced a constant pressure, even in project planning sessions, to reduce staff levels and budgets even further.

In particular, Watkins noted that, while Harold Smith had some excellent ideas for new projects, their implementation "would require much planning and considerable funds" as compared to more straightforward proposals on the study of oil field brines proposed from the station.[24] After the meeting, the Petroleum Production Steering Committee recommended that all funding remain at the same levels in the five various divisions working on production problems. Duplicate work would be ended, and the laboratory at the Dallas Field Office closed. Facing a fixed budget, the wisest way to increase availability of money was to eliminate duplication. According to Watkins, requests for expanded funding were simply not a reasonable alternative.[25] Furthermore, the steering committee saw a danger in the search for outside cooperative funding that might redirect a whole program. The committee recommended "that cooperative efforts (including grants of funds) be undertaken only when the work involved support work already in operation . . . thereby recognizing that grants of money as such should not influence the nature of our program."[26] Such caution about funding no doubt contributed to the rigidity of the station and its slow response to new opportunities.

Fowler and others at the station attributed some of the stagnation of the 1950s to the state of the art itself, rather than to their own administrative and policy decisions. Fowler believed that great scientific progress had been made during the war years, but that technological research had too often "gone to the well" of advances made under the pressures of the war. Put another way, progress had reached a plateau due to the working out of the technical consequences of wartime advances, and a new, massive stimulus was required. Such a view ignored the fact that a great many new opportunities for technical work came out of the contemporary oil economy, the problems and the technological issues of the decade.

The total staff did not react with caution and adherence to old patterns, however. Some of the new opportunities were noted, and some pursued by men at the station. Studies in diesel fuel, auto emissions, pipelines, secondary recovery and waterflood methodology, rocket fuel, and the use of radioactive tracers, together with long-range projects studying thermodynamic properties of sulfur compounds in petroleum and pressure-volume-temperature relations in condensate gas wells, all came out during the Fowler years.

In addition, some of the more enterprising staff members of the Bartlesville station began to get a few contracts to do research work for other government agencies, in effect, establishing a relationship with other branches of the federal government that resembled that of a private contracting firm to private clients.

One case which illustrates this particularly well is the career of Richard Hurn. Hurn had earned B.S. and M.S. degrees in mechanical engineering, and came to the station in 1948. Brought in because some of his graduate work had concentrated upon diesel fuels, he worked first in the Chemistry and Refining Branch, heading the engine laboratory that had been set up to test aviation fuels during the war. Hurn's work came in response to the greatly increased demand for diesel and for knowledge about diesel fuels, resulting from the conversion of railroads from steam to diesel engines, as well as from the growth of diesel engine use in the trucking industry. He developed a combustion chamber to study diesel processes, and worked on characterizing diesel fuels and issues related to stability and fuel compatibility. With respect to the latter, the problem was that unstable diesel fuels produced by cracking processes tended in storage to produce gums; incompatible cracked fuels, when mixed in storage, tended to lay down a sludge.

By 1951, Hurn completed the diesel work and turned his attention to problems of exhaust gases, not because of an internal policy decision of the station or the Bureau, but because of increased interest in smog by agencies outside the Bureau. In this regard, he violated the steering committee recommendation that outside funding not be allowed to shape programs. The constant volume combustion bomb that Hurn had developed to study diesel combustion gases could be used to study smog problems. Hurn raised outside money—not only accepting an increasing reliance on cooperative funds as a necessary part of getting research funding, but even welcoming the adjustment to priorities, set not by a Bureau committee, by the regional office, or by Washington, but by broader economic and political developments entirely outside of the federal government.

In the mid-1950s, Hurn, working in Harold Smith's group, made a minor administrative decision which reflected his approach and which ran head-on into the conservative strategies of Fowler. Hurn reasoned that the station should no longer participate in a regional exchange group set up during the war to verify local octane testing procedures. The practice was for samples of fuel tested by other private and university laboratories to be sent to the station. Test results of the octane level, when compared with other laboratories' results, would then determine whether standard testing engines at the station produced standard results. However, by the mid-1950s, the station's test engines were no longer used to determine octanes except for this special purpose, and Hurn sought to withdraw from the exchange group so that the engines would no longer have to be diverted from their main purpose of testing for smog.

When Fowler heard of Hurn's decision, he called Hurn in and asked him to explain the action. Hurn stated that there was no longer a need for such participation.

"But the exchange group is an institution here," said Fowler.

Hurn replied that he had not been hired to maintain an institution, but to do work. Since filling out the reports to the exchange group used resources and time better spent on productive work, he thought it perfectly logical to bring the participation to an end. Hurn later remarked that Fowler then became quite angry. Fowler believed Hurn had exceeded his authority and had diminished one hard-won and established method of receiving at least regional recognition. Hurn perceived Fowler's attitude as a case of institutional inertia—inertia which, Hurn believed, was precisely why the station no longer commanded the respect of the wider scientific and industrial community.[27]

Hurn continued to build contacts with individuals in industry, in local and state governments, and in federal agencies. Yet it was clear that men like Hurn, a self-confessed "maverick," were the exception, not the rule, at the station through the 1950s. He worked aggressively and with increasing success to find new research areas and outside funding. Few others at the center in the 1950s had his combination of abrasive independence of mind, energy, drive, and willingness to work closely with people in the regulatory agencies.

C. C. Ward, who succeeded Harold Smith as head of the Petroleum Chemistry and Refining section, also exercised some ingenuity in shopping around for funding sources. He worked to obtain $15,000 funding from the Western Petroleum Refiners Association in 1954 for the study of trace metals in petroleum, securing the placement of the project on the Association agenda in 1955. Trace metals such as vanadium, nickel, and iron reacted with catalysts in the cracking process, causing financial loss to refiners by ruining the catalytic crackers. Guy Waddington suggested in 1955 that the topic was "hot" and should be part of the program of the station.[28]

Ward also obtained funding from the Navy's Bureau of Ships to study the cause of diesel fuel instability. Following up on the earlier work by Hurn and Harold Smith on this topic, the section undertook to study oxidation of pure hydrocarbons at low temperatures and to develop methods to remove the most unstable hydrocarbon compounds from the fuels. In 1957, Ward worked to get the Bureau of Ships to extend the contract, particularly to study methods of removal of sulfur, nitrogen, and oxygen compounds which appeared most involved in the gum-forming process. Ward's modest budget of $12,000 to extend the work through 1958 at first appeared doomed by a lowered budget for research at the Navy's Bureau of Ships. In January 1958, however, Ward received word from his contacts in the Navy that the project would be supported.[29]

Always on the lookout for new money, Ward discussed with his Navy contacts potential Bartlesville work on "hypergolic" mixtures—the mix of oxygen and oxidizers used in missile fuels, keeping an eye on this possibly rich source of funding. However, no rocket work was forthcoming in 1958–1959.[30]

Ward's constant search for outside funding strengthened his branch, and by the end of the decade, the Chemistry and Refining section could anticipate continued expansion.

Ward, working as Hurn's supervisor, showed a style of administration and liaison that was considerably more diplomatic than Hurn's. Ward kept Fowler posted on all his contacts with outside sources, and worked closely with him on matters of budget. Ward's achievement of outside funding, rather than generating friction with Fowler, set a pattern of support that held promise of future growth. His style eventually, however, as will be discussed further in Chapter 6, led to friction with Hurn, who began to perceive him as too conservative.

A third example of funding ingenuity was R. Vincent Smith, a physical chemist with an M.A. from the University of Missouri at Columbia, who had joined the station in 1936, working first with Eilerts on phase relations of condensate gas. For a brief period in 1940–1941, he worked with M. A. Schellhardt and then continued with Eilerts through the war and early post-war years, co-authoring parts of Eilert's massive monograph. In 1949, he began work on projects of his own, concentrating on the issue of friction in gas pipelines. The rapid growth of pipelines for natural gas, crude oil, and for finished products like gasoline created a demand for studies of friction in pipelines and for principles that could lead to improved design. By 1954, he had completed work, under a continuing grant from the American Gas Association, which provided the basic calculations for construction of gas pipelines to determine optimum pipeline diameter and the spacing of compression stations. The AGA continued the funding, at least in part because Cattell at headquarters worked closely with Eddie Rawlins, Bartlesville alumnus, who served as chief engineer at Union Producing Company and as Chairman of the Gas Well Deliveries Subcommittee of the AGA. Vincent Smith's study provided a means of reducing to mathematical formulas the friction that slowed gas flow through pipelines. This work became widely cited and used in the pipeline expansion of the 1950s.[31]

Smith resigned from the Bureau in 1954 and went to work for the natural gas division of Phillips Petroleum, where he headed a team that produced technical and economic analysis of gas pipeline construction problems. As a physical chemist, Smith had gained experience in engineering issues in his twenty years at the station and then, like the technicians of the 1920s, transferred both his academic training and his rich field experience to the private sector. His work, like earlier projects in the 1930s, attracted the notice of a rapidly expanding sector of the petroleum business and provided basic nonproprietary data that were widely utilized, and, like that of Hurn and Ward, was eagerly accepted and funded by groups outside the Bureau of Mines.[32]

Technology Transfer

In several areas, Fowler did attempt to respond, in his own way, to new opportunities. In the parlance of a later generation, Bartlesville could facilitate "technology transfer," both from the government's own atomic energy program to the domestic oil industry and, in a broader sense, from the United States pool of technical know-how to the rest of the world—as petroleum fields developed in Latin America, the Middle East, and elsewhere. Fowler made efforts in both directions, with varying degress of success.

The burgeoning production of radioactive isotopes from the atomic energy program provided a new tool; isotopes could be used as tracers in the study of flow of fluids in underground formations. Although Taliaferro and Fowler hoped to adapt to the new developments spun off from the atomic energy program by developing both equipment and skills to use radioactive isotopes as tracers, and to construct a separate special laboratory for the purpose, inability to attract funding prevented the project from getting off the ground.[33]

Wade Watkins arranged for F. E. Armstrong, an electrical aide at the station, to take a special course in instrumentation for work with radioactive isotopes at the Oak Ridge Institute of Nuclear Studies in 1949. Watkins recommended Armstrong highly to Oak Ridge and worked for his admission to the study program. However, funding was so limited in fiscal years 1949–1950 that money could not be spared for the training or the whole development of an isotope-tracer program for petroleum use.[34]

The first isotope study at Bartlesville was not conducted, therefore, until 1952. It traced iodine-131 placed in the strata through a water injection well and measured its outflow through four surrounding producing wells. This method held the promise of establishing optimum spacing of injection and producing wells in varied strata conditions.[35] But the project was "hampered seriously" through 1954, according to Taliaferro, since only one physical chemist and one electronics engineer could be spared to work on it. Through 1954 and 1955, the station sought cooperative funding from the Atomic Energy Commission to aid in the project, but in vain.[36]

Overseas, the expansion of United States firms led to the need to train foreign nationals in United States petroleum technology, opening an opportunity for the station to provide a new service. By bringing foreign technicians to the station for an extended visit, the station could obtain the benefit of their services and, at the same time, assist the petroleum firms in developing an experienced cadre of foreign nationals who could work in overseas locations. The political advantages to United States firms could be considerable, in that such efforts would help respond to pressures in the overseas locations to staff firms with local people and to get some local economic benefits from exploitation of resources.

In 1951, the station accepted some twenty foreign technicians for study from Venezuela, Iran, France, Italy, Egypt, Mexico, Canada, Japan, Sweden, Uruguay, and Great Britain. Most were early in their careers, less than thirty years of age, and came under a variety of international exchange programs from both universities and industry. Similar groups came each year through the 1950s.[37]

Petroleum developments overseas produced another possible avenue for station service, that is, sending station personnel to foreign nations which had already nationalized their oil industries. On a government-to-government basis, the station could provide consultation, advice, and possibly on-site training. One of the first such opportunities for the station came in the early 1950s.

In the summer of 1952, Taliaferro visited Yugoslavia under United Nations auspices. The bureaucratic impediments to the trip were severe—he had to take a leave of absence without pay from the station and be placed on a temporary payroll of the Technical Assistance Administration of the United Nations. As a result of the move begun in 1948 to break off close relations with Moscow, Yugoslavia had requested U.N. assistance in ninety different technical areas as part of its move to modernize the nation without reliance upon Soviet technical experts.

Taliaferro spent most of his time at the Petroleum Institute in Zagreb and in oil fields in Croatia and Slavonia. He reported that the Yugoslavs' oil industry, developed by the Germans during World War II, was in considerable disarray with an odd assortment of equipment from Italy, Germany, Russia, France, and the United States.

Taliaferro offered comments and recommendations, particularly regarding equipment modernization. However, due to the language barrier, what Taliaferro himself saw as a relatively low level of importance attached to the advice in Yugoslavia, and the severely constrained resources of the Yugoslavs, the work seemed to have little lasting impact. Taliaferro's trip brought some local press attention to the station in Oklahoma, but it did not lead to an immediate follow-up program of work in foreign fields.[38]

Technology transfer included a variety of meetings and activities. The waterflood tours served to demonstrate new techniques to local producers. Annual meetings of the American Petroleum Institute advisory committees provided a forum for transfer of government research to the private sector. Through the 1950s, an annual Diesel Conference brought together diesel engine manufacturers and diesel fuel refiners for discussion of research. As with Huffman's Calorimetry Conference, an annual meeting of thermodynamicists, these regular meetings provided not only a channel for research to flow to industry, but also allowed contact and ideas for the renewal of projects and discussion of new private funding to the Bartlesville station. Concerted liaison with industry, thus, helped the station survive and even flourish in particular areas.

Survival Under Siege

By 1955, Fowler had developed an explicit style of response to the period's financial and structural limits and the new opportunities. He supported the concept that station superintendents, together with their branch chiefs and individual researchers, should initiate projects. He opposed the effort to set up a higher coordinating level under regional directors. He argued for the addition of a "writing engineer" to the staff who could help in the polishing of manuscripts, and he worked toward timely publication of results, attempting to maintain the tradition of excellence begun under Superintendent Smith.

When it came to outside funding, Fowler increasingly recognized the growing significance of outside cooperative funding from associations. At first he remained very cautious, warning that outside funding should not substitute for federal allotments but should, instead, make possible the "best use of the Federal allotments." Yet, over time, he developed a host of outside-funded projects. Fowler attempted to protect personnel from being laid off during funding cutbacks, worked to keep lively projects going, tried to avoid duplication of effort with other branches of the Bureau, and struggled to maintain the level of recognition and achievement built up by Smith through the 1930s and the war years.[39]

For those who lived through the period, the issue of why the station entered a time of alternation between stagnation and readjustment remains extremely hard to understand even in retrospect. Some veterans of the period tend to view the issues entirely in personality terms, attributing friction and morale problems to the individuals involved. And, on the small stage of the laboratory, personality conflicts and tensions were indeed real factors. But equally clearly, the station also faced limitations which, when viewed in perspective, stemmed from outside forces as well as from the traits and style of those in charge at the time.

Hurn's development of an air pollution program and the increased work in secondary recovery in response to local interest provided the station with continuing strength, attention, and some notable successes. Constant searches for new projects, some quite small, by Branch Chief Ward enlivened the work of the Chemistry group. Routine work on fuel surveys, which year-in and year-out summarized reports on octane testing provided by industry itself and on locally requested field surveys, together with the gradual and steady progress by Eilerts and the thermodynamics group, also kept the technical and industrial community informed that the Bureau of Mines station at Bartlesville was still at work.

By the end of the 1950s, the station had fully adjusted to change. Its work had found a place despite the tensions between major integrated multinational firms, with their increased reliance on imported oil, and the mid-continent producers who continued to rely on government research to aid in the development of secondary recovery methods. The internal tensions over personnel and budget had been weathered. Engineers and scientists had maintained an uneasy truce and continued to take pride in each other's major accomplishments. Restrained federal budgets had limited the station's growth, but the careful building of outside funding had set a pattern that could provide a means of continued growth. The siege had been difficult, but the station was ready to respond to new opportunities in research and technology which would come in the 1960s.

NOTES

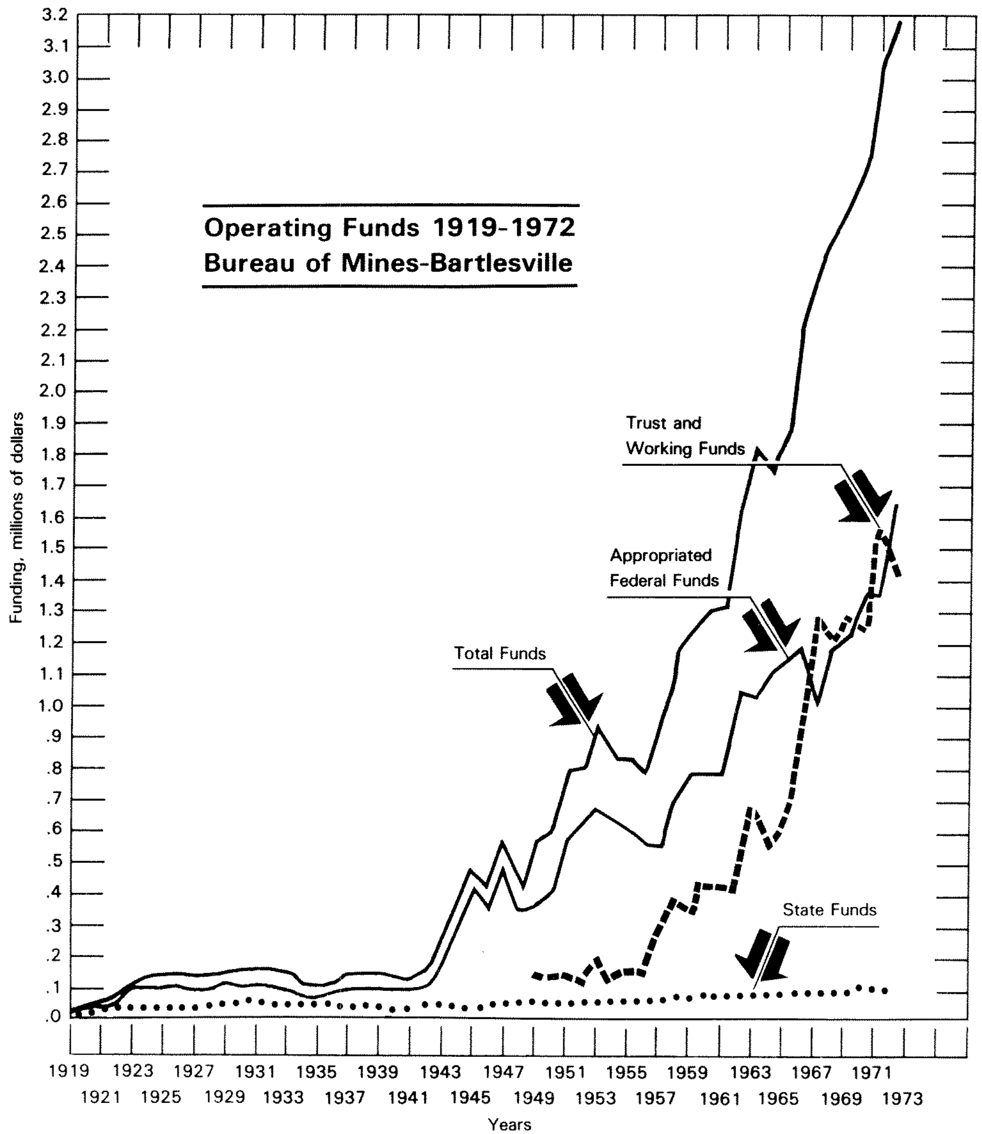
1. Fowler to R. F. Anderson, February 8, 1955, Box 324908/Project References.
2. Box 324908/Steering Committee-Production; Fowler to Anderson, August 18, 1949, Box 224340/050 Director's Annual Report.
3. Fowler to Rue, November 15, 1945, Box 224340/150. 2 Reductions in Force.
4. Rue to Fowler, November 28, 1945, Box 224340/150. 2 Reductions in Force.
5. Report to Advisory Committee on Secondary Recovery, Estes Park, Colorado, September 1, 1949, Box 324908/Work of the Station.
6. Fowler to Anderson, November 29, 1948, encl. proposal, Box 224338/621.3 Synthetic Fuels.
7. *Ibid.* Crauford D. Goodwin, "The Truman Administration:

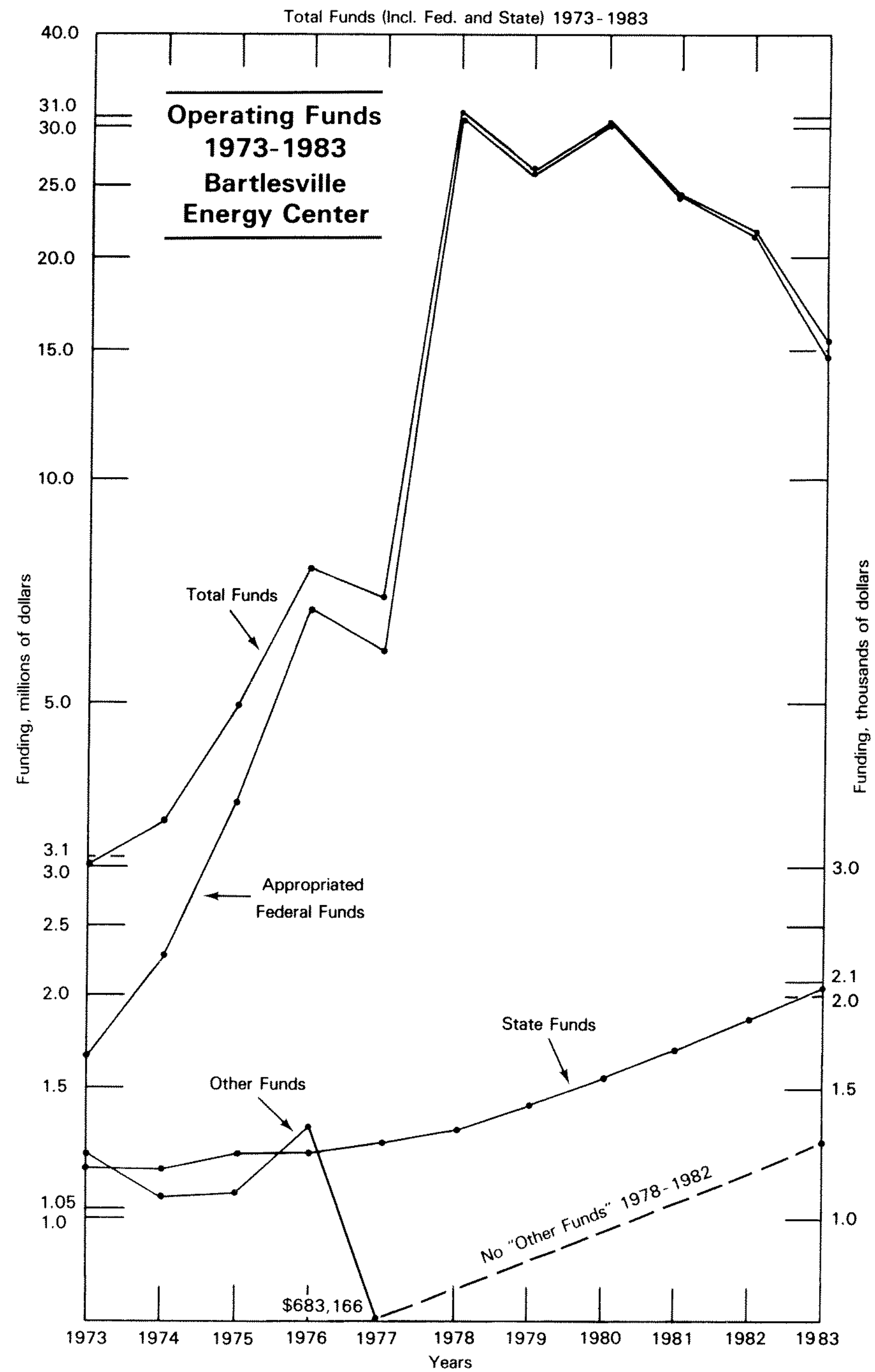
Toward a National Energy Policy," 1-62, and "Truman Administration Policies Toward Particular Fuels" (Petroleum), 63-129, (Synthetic Fuels), 146-166; William F. Barber, "The Eisenhower Energy Policy: Reluctant Intervention," 205-286; in *Today's Problems, Yesterday's Solutions* (The Brookings Institution, Washington, 1981).

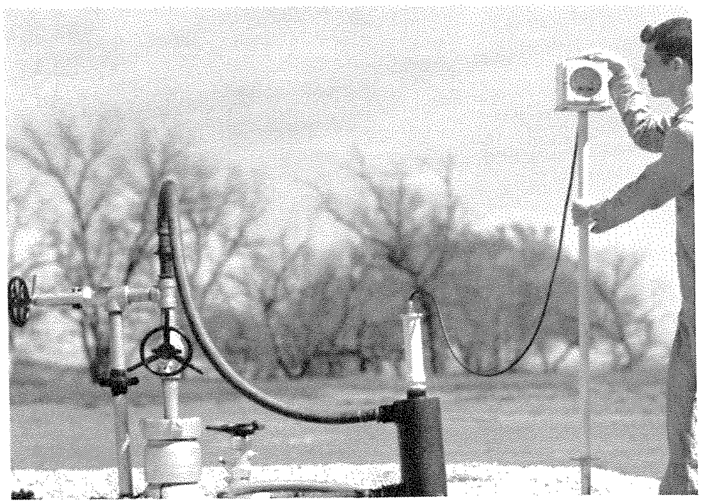
8. Ambrose to Fowler, November 21, 1947; Fowler to Ambrose, November 19, 1947, Box 224336/612.23 Shale Lab Work.
9. Fowler to Lankford, 1948, Box 224336/612.23 Shale Lab.

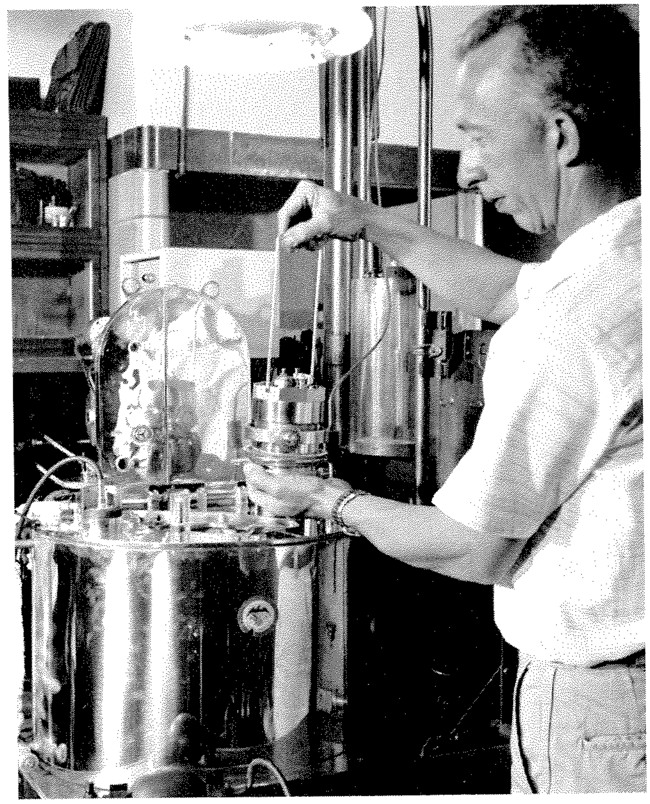
9a. Gooding to H. M. Smith, March 11, 1948, Box 22436/612.33 Shale Lab Work.

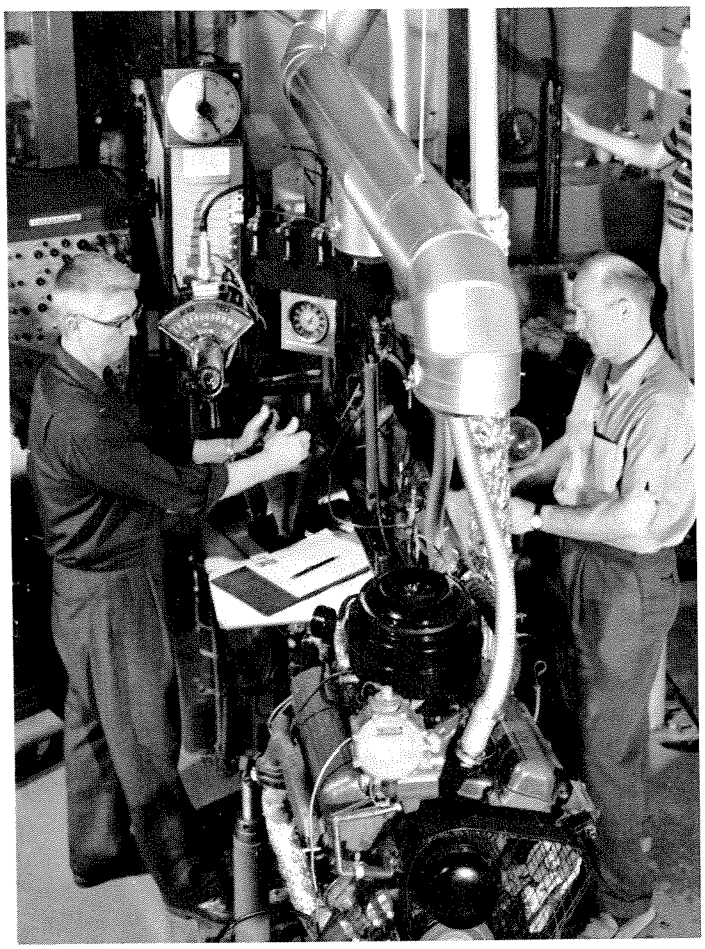
10. Box 224333/Reports, Fowler, June 1946.
11. Interview Carlisle-Kenneth Johnston.
12. Fowler to Cattell, November 7, 1947, and Guthrie to Cattell, October 30, 1947, Box 224335/831.15 Texas-Red River; Riggs to Producers, August 19, 1948, Box 224338/ 531.32 Healdton; Box 228338/831.194 SE Kansas-Bundred Oil Company Study.
13. Fowler to Cattell, February 3, 1956, Box 3249O8/Steering Committee-Production.
14. Cattell to Chief, Office of Mineral Reports, January 27, 1953, Box 224344/017.407 Cattell, RA; Fowler to Cattell, February 4, 1953, same folder.
15. Fowler to Smith, April 1, 1955, Box 324908/Project Reference.
16. Fowler to Anderson, August 18, 1949, Box 224340/050 Director's Annual Report.
17. Fowler Tech Report, July 1952, Box 224344/017.41 Bartlesville.
18. D. B. Taliaferro, "Recommendations on Improvements in the Work of the Division," Box 324908/Steering Committee.
19. Watkins to Smith via Fowler, March 25, 1955, Box 324908/ Project Reference.
20. Smith to Fowler, July 20, 1956, August 10, 1956, Box 324908.
21. Eilerts to Low, February 3, 1953, RG 70, FN NARS, Box 224344/019.121 Patents of Employees; interviews Carlisle-Burman, Carlisle-Eilerts.
22. Interview Carlisle-Eilerts.
23. Watkins to Taliaferro, February 28, 1955, Box 324908/ Project References.
24. *Ibid.*
25. Cattell to Fowler, January 20, 1956, Box 324308/Steering Committee.
26. C. J. Wilhelm to Cattell, February 16, 1956, Box 324908.
27. Interview Carlisle-Hurn.
28. Waddington to Fowler, January 24, 1955, Box 324908/ Project Reference.
29. Ward to Kelley, November 13, 1957, January 31, 1958, BETC Vault 826.85.
30. *Ibid.*
31. Interview Carlisle-R. V. Smith.
32. Cattell to Rawlins, April 13, 1951, Box 224342/Fowler Files. Monograph 7 "Back-Pressure Data on Natural-Gas Wells and Their Application to Production Practices"; Monograph 10–"Phase Relations of Gas-Condensate Fluids."
33. Taliaferro to Anderson, April 19, 1949, Box 224338/468 Tracer Studies.
34. Watkins to Overman, June 17, 1949, June 29, 1949, Box 224338/468 Tracer Studies.
35. Box 224344/017.41 Technical Report, September 1952.
36. Watkins to Taliaferro, February 28, 1955, Box 324908/ Project References.
37. *Bartlesville Record* Clipping, June 12, 1951, Box 324908/ Work of the Station.
38. Box 224344/017.407 Taliaferro's Yugoslavia Trip (1952).
39. Fowler to Smith, June 10, 1955, Box 324908/Project References.

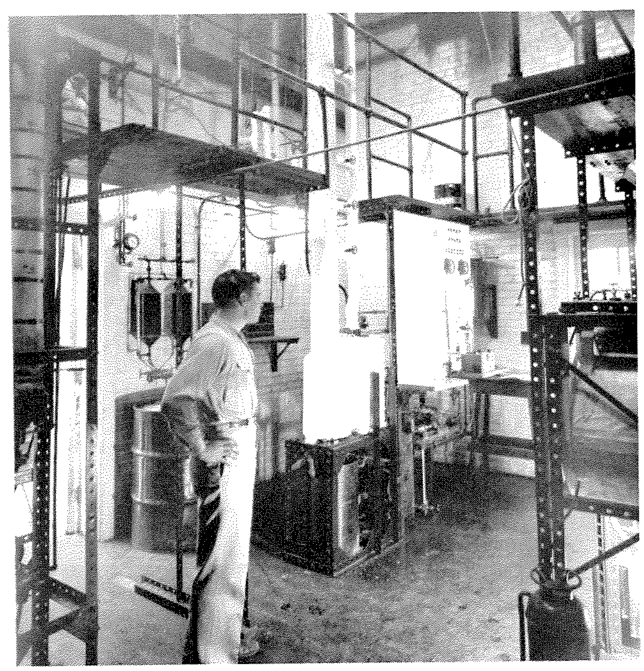

Operating Funds 1919-1972
Bureau of Mines-Bartlesville
Funding, millions of dollars
Years
Trust and Working Funds
Appropriated Federal Funds
Total Funds
State Funds


Total Funds (Incl. Fed. and State) 1973-1983
Operating Funds 1973-1983
Bartlesville Energy Center
Funding, millions of dollars
Funding, thousands of dollars
Years
Total Funds
Appropriated Federal Funds
State Funds
Other Funds
$683,166
No "Other Funds" 1978-1982



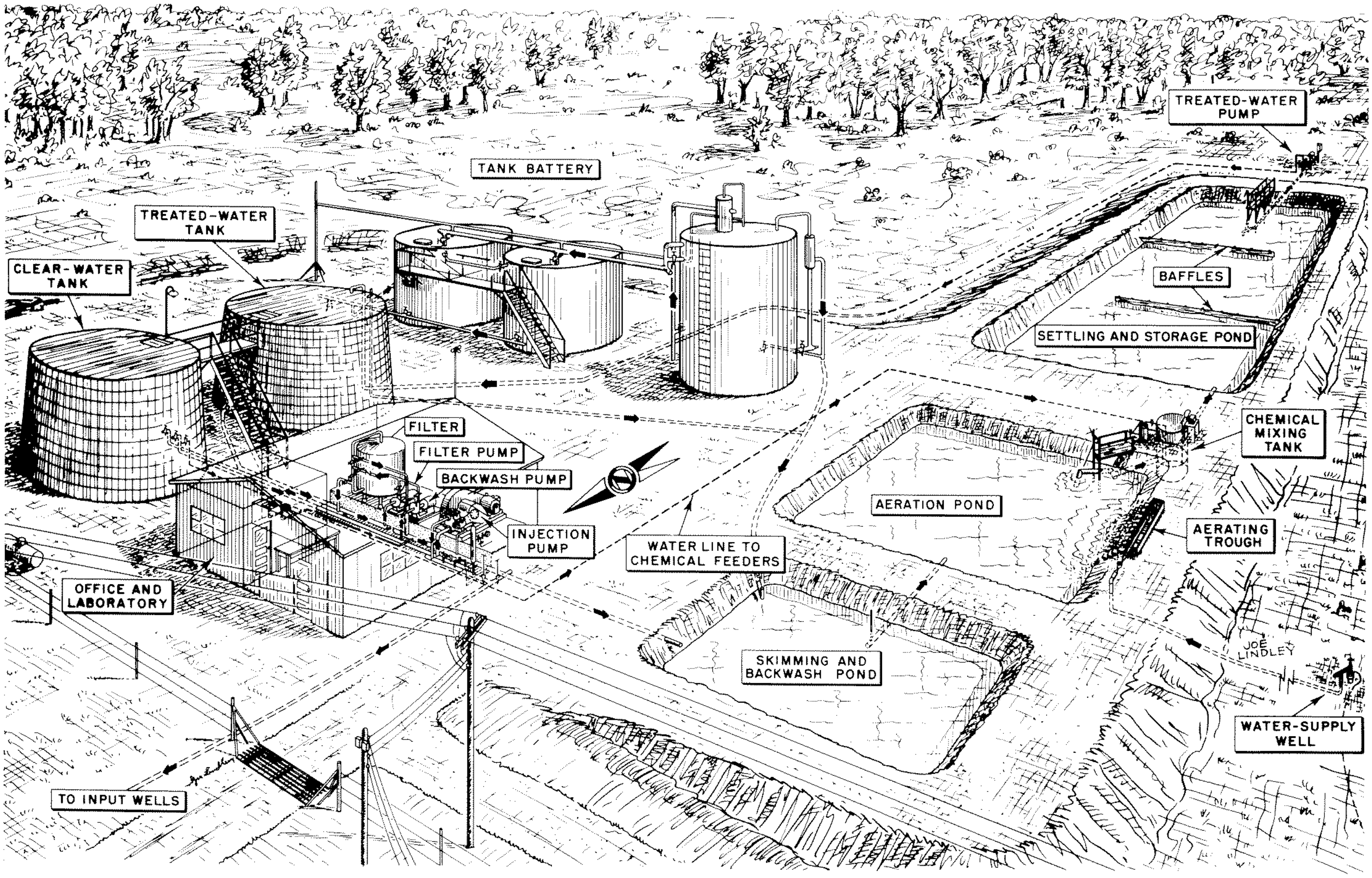


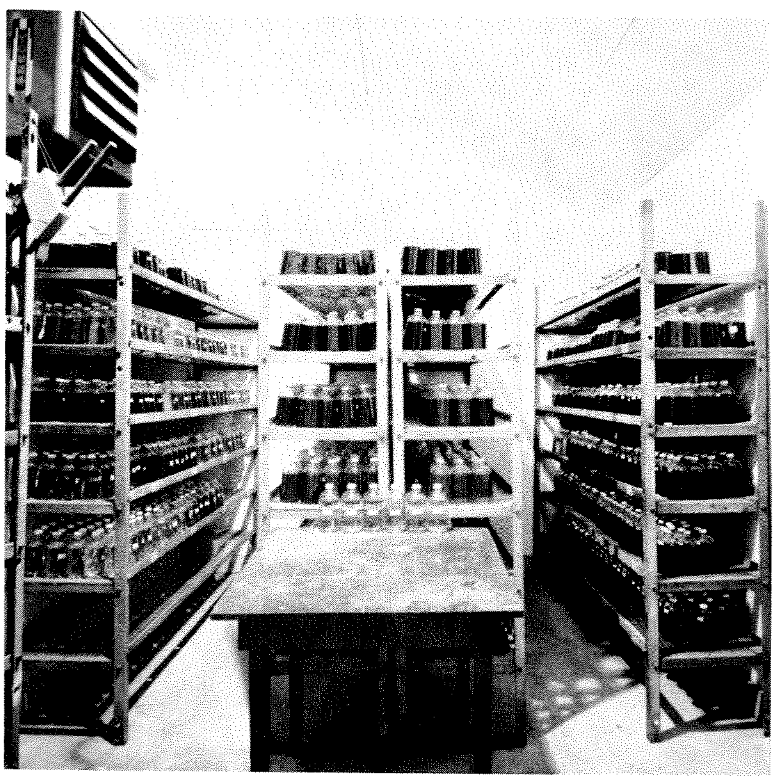




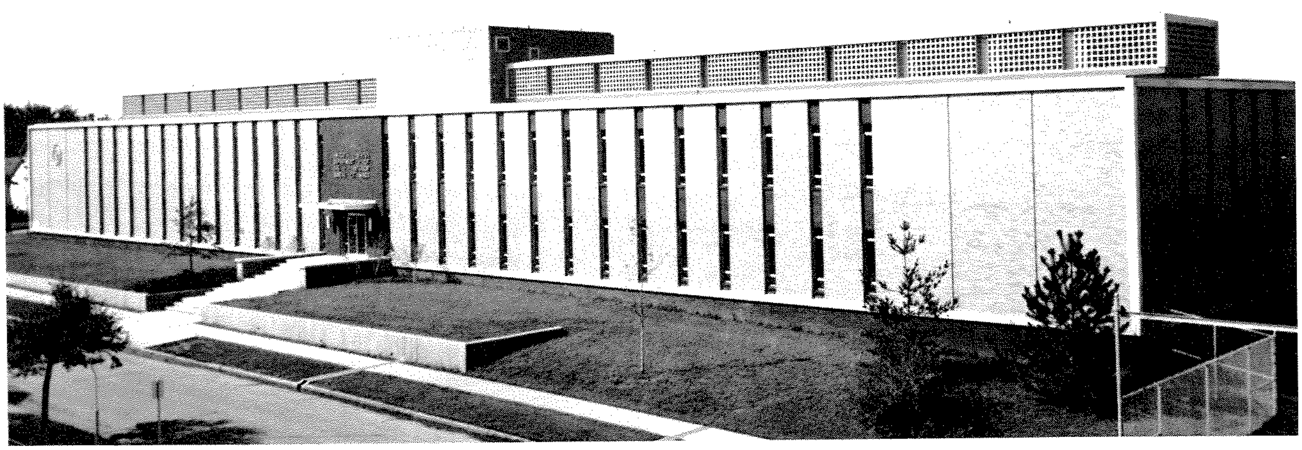
Evolving Research Frontiers

The 1950s brought a new set of problems to the Bartlesville Petroleum Research Center. Low-level radioactive tracers were injected (upper left) into oil-bearing formations by Engineer Bill Howell to determine the flow path. Heats of combustion of difficultly-combustible compounds were determined in a bomb developed at Bartlesville (upper right), operated by Chemist Bill Good. Growing interest in the smog problem and its connection with automobile exhaust prompted experiments to determine the mechanism (lower left). The importance of composition of crude oil to refiners required distilling many crude oils in order to analyze them (lower right).

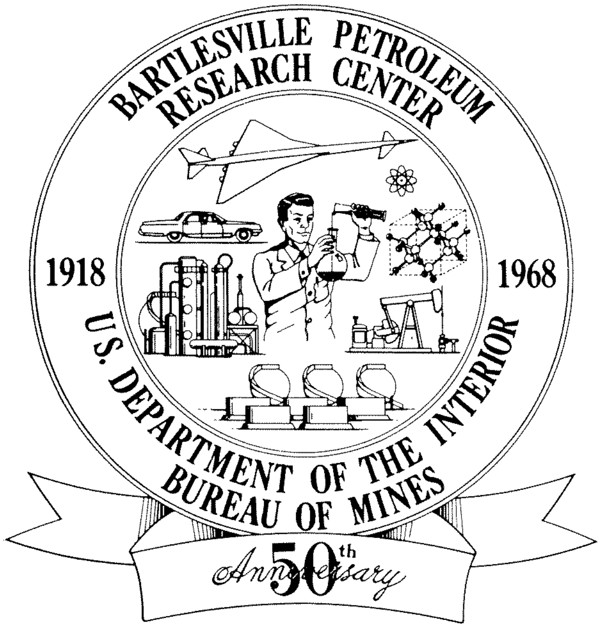


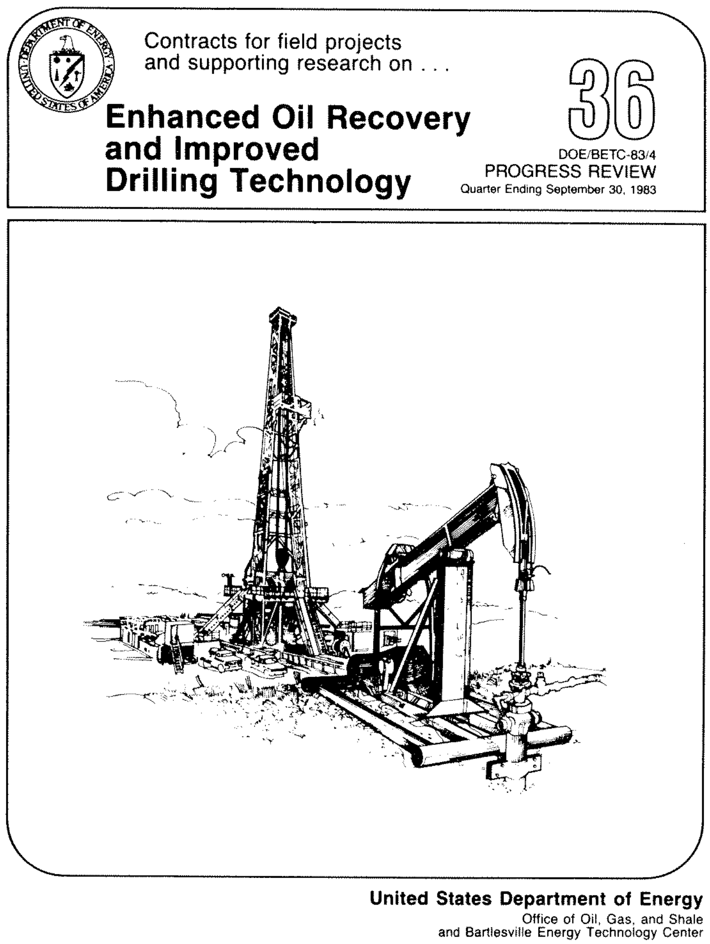


For the waterflood tours, a description of the projects to be visited was prepared ahead of time. One feature of these publications was a schematic (upper picture) of the waterflood prepared by Joe Lindley, BETC illustrator. Studies of the stability of petroleum products were carried out for the armed services over the period 1950–1980. One feature of these was the storage of samples of oil for a given time at elevated temperatures in the "hot room" (lower picture).



The increasing importance of secondary recovery in the 1950s was recognized in the waterflood tours in which groups of producers were taken to model operations by automobile caravans. The upper picture shows a group at a project in Anderson County, Kansas in 1953. Continued growth of the Center called for expansion of facilities and the Engineering and Physical Science Building (lower) was dedicated in 1963. By this time the Center had grown to 170 persons whose expertise covered many scientific areas affecting petroleum. The Fiftieth Anniversary celebration in 1968 brought special recognition to the Center.





Contracts for field projects and supporting research on . . .

Enhanced Oil Recovery and Improved Drilling Technology

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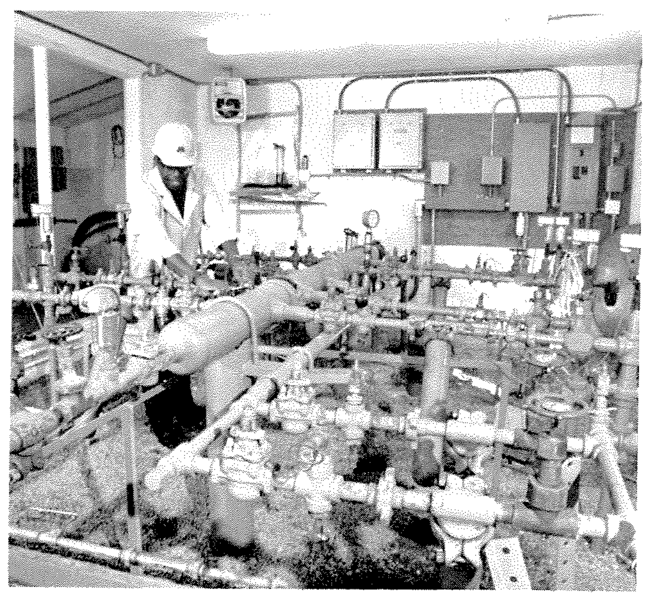
DOE/BETC-83/4
PROGRESS REVIEW
Quarter Ending September 30, 1983

United States Department of Energy
Office of Oil, Gas, and Shale
and Bartlesville Energy Technology Center



Technology Transfer has been an important part of the program at BETC. The waterflood tours and associated meetings and publications were the main forum in the 1950s. In 1968, the Center celebrated its 50th Anniversary and the logo (upper left) was an important symbol of it. Starting in 1975, Progress Reviews on Enhanced Oil Recovery were published quarterly (upper right). A companion publication was *Liquid Fossil Fuels Technology*, published quarterly from 1980–1983. Shown in lower left is Editor Bill Linville checking quality of this publication. Another feature of technology transfer was field projects, and the control room in the Nowata Micellar-Polymer project is shown. Ray Jones is the technician (lower right).